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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: D.5

Philipoines

INDUSTRIALISATION OF COCONUT PRODUCTS AND BY-PRODUCTS

By CANUTO G. MANUEL, D.Sc.,
Commissioner
National Institute
of Science and Technology

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INDUSTRIALIZATION OF COCONUT PRODUCTS AND BY-PRODUCTS

BY CANUTO G. MANUEL, D.Sc
Commissioner
National Institute of Science and Technology

Introduction

1. The coconut is the premier income-producing export crop in the Philippines. With an annual harvest of eight billion nuts (about 9 million tons) and a production during calendar year 1961 of 694,295 long tons of copra valued at $99,043,840 and 72,400 long tons of copra oil valued at $15,310,345, the Philippine is the world's biggest nut and copra producer. Other principal coco products exported in 1961 are copra cake-meal valued at $3,493,256 and dessicated coconut valued at $14,351,060. As such, the coconut industry, upon which about 1/3 of the Philippine population (around 9 million) depend wholly or partly for their livelihood, is the backbone of the nation's economy. 1/

2. However, the status of the industry, even with its present contribution to the country's economy as the above data indicate, is not stable, its future uncertain because of two factors: the threat of "cadang-cadang" disease of coconut trees and the increasing competition from synthetic detergents in foreign markets. The income derived from the industry represents only a small portion, about 20% of the total amount that can actually be obtained if all parts of the fresh matured nut is completely utilized and industrially developed into various higher-priced consumer commodities, considering that at present crudely-processed, low quality copra and poor quality copra oil are only the main produce. Only 20% of the whole nut is now being utilized, 80% go to waste.

3. The coconut therefore ranks foremost in potentialities for industrialization. It is in this area where the top-priority application of science and technology has been considered by the National Institute of Science and Technology (NIST)

1/ Data cited taken from 1961 Annual Report of the Philippine Coconut Administration and other statistical records of the same office.

as the most promising in terms of results that will tremendously enhance Philippine socio-economic progress.

The Five-Year Coconut Industrialization Program

4. The NIST, formerly the Bureau of Science, was reorganized, its functions and facilities expanded in July 1958 by the Philippine Science Act of 1958 and has been charged with undertaking research and development activities in the conventional sciences, particularly in fields selected as to their impact to the national economy and to their relation to the needs of existing and/or possible future industries. Being a developing country the direction and application of science and technology to our research and development efforts require that priority consideration is given to the exploitation of our more abundant native raw materials to increase exports and reduce imports and generate more job opportunities for our rural population.

5. The NIST, in accordance with the criteria of its governing National Science Development Board for program/area priorities of food, clothing, shelter and medicinals, and its own criteria for priority rating of specific research and development projects has, among its several areas of research, given top-priority to the industrialization of coconut products and by-products. In the formulation of this program, it was deemed of economic necessity that the coconut industry should be diversified and oriented towards new directions of development and growth. The economic value of the coconut can be greatly increased by developing the vast food product potential of the coconut industry and gradually eliminating primitive copra making.

6. The NIST 5-year research program (1961-1966) for the coconut consists of two complimentary and simultaneous phases, the laboratory research phase and the pilot plant development phase. Under the first phase, inter-related research problems selected after thorough literature survey and project evaluation are being undertaken with the object of finding new, technologically and economically feasible process or processes of producing specific end-products, or improving and adapting already known industrial process or processes to suit local materials and conditions. Experimental projects completed in the laboratory are tried or tested under pilot plant conditions to obtain more reliable technico-economic data as bases for commercial scale production.

7. The primary objective of the program is the development of an optimum integrated process for the complete utilization of the components of the coconut including husk and the design and construction of a continuous coconut by-products processing plant utilizing fresh matured nut as the raw material.

8. Coordinated work operations on selected projects under this program being undertaken by the Institute's Industrial Research Center have been divided/

distributed to several teams of coconut researchers based on specific raw material to be used and end-product objectives, to wit; (a) projects centered on the husk; (b) projects centered on the shell; (c) projects centered on the meat and oil; and (d) projects centered on the coco water.

Research Projects Centered on the Husk

9. The components of the husk that could be industrially utilized are (a) the long (bristle) fibers - 10%; (b) the short (mattress) fibers - 25%; and (c) the coir dusts - 65%. A very insignificant portion of the total husks output of copra making is being utilized in the small local home industry level for the manufacture of ropes, twines, doormats, brushes, floor carpets and cushion materials for upholstery products. Almost 90% of husk raw materials are thrown away as waste in coconut growing provinces.

10. The objective of the NIST project on the coco husk is the development of an optimum processing method of converting husks into marketable products, particularly for pulp and thermal insulating materials. The end-product objective of another research project is the utilization of the short fibers and coir dusts for the manufacture of hard boards. A related ongoing project is the extraction of the lignin content of the husk and a subsequent study on its commercial value. A microbiological method of retting coco husks in order to improve the spinning quality of coco fibers is also being undertaken.

11. Under the engineering aspect related to husk utilization studies are two projects: (a) fabrication from an improved design of a mechanical dehusking machine, and (b) design, development and construction of an automatic, electronic coconut maturity sorter for husked or unhusked coconuts to separate the young from the matured nuts without slowing down the flow of nuts in a conveyor belt.

Research Projects Centered on the Shell

12. Research projects on this coco component are concentrated on four marketable end-product objectives: (a) grinding the shell and, by flash carbonizing, recover the distillate as crude creosote; (b) recovering the charcoal and processing these into briquetted charcoal fuel without using binders; (c) processing the charcoal to produce carbon black or carbon electrodes, and (d) processing the shell by using an NIST-developed method to extract and produce furfural.

13. On the engineering-equipment side, developmental studies are centered on the design and fabrication of a mechanical de-shelling machine that can efficiently and rapidly remove the fresh coco shell without breaking the meat and the fabrication of a mechanical coconut paring machine for removing the brown coating of the meat.

Research Projects Centered on the Meat

14. The coconut meat is by far the most important component of the coconut and the greatest source of many commercial higher-priced by-products, especially food products required to augment the food needs of a fast-growing Philippine population which is increasing at a rate of 3.2% per annum.

15. Preliminary economic-profitability studies in the NIST have shown that more income will be derived from the meat by utilizing it as a material for various food products than when made into copra. Hence, concentration of NIST research and development work is on the meat in order to produce in marketable form "granulated coconut" as the main product by fluidized bed method.

16. Other major coco food projects are on the production of high-grade, water-white edible oil with low fatty acid (dry process), coconut sweetened condensed milk, coco breakfast food from coco flour, coco cheese, coco soft drink and coco protein.

17. Coconut oil as a source of a potent biological insecticide is also being investigated. Studies on the utilization of coconut oil soapstock by esterification of the fatty acids for the production of quarternary ammonium compounds is also underway.

18. Completed laboratory research projects being readied for pilot plant trials (development phase) are described under separate items in ensuing paragraphs.

Research Projects Centered on the Coco Water

19. Research studies on the utilization of this coconut component are centered on two major projects: (a) its uses as a medium in a microbiological process of producing (by means of a polysaccharide) a thermoplastic material that can be used for paint lacquer and plastic materials; and (b) its use for the propagation of protein-rich and Vitamin B-rich food yeast using a strain of Torulopsis utilis (Henneberg) Lodder.

Completed Laboratory Research Projects: Development Aspects

20. The new approach to the main coconut project of the NIST is the development of an integrated continuous process for the full utilization of the coconut which combines the following steps: (a) husking the coconuts; (b) shredding the husks and separating the long fibers, short fibers and the coir dusts; (c) processing the fibers and coir dusts into either pulp or for construction materials; (d) shelling the dehusked nuts; (e) grinding the shells and other husk wastes and carbonizing the mixture, recovering the creosote distillate and separately recovering

the charcoal for briquetting or for carbon electrodes or carbon black; (f) grinding the cleaned meat to micron size; (g) drying the ground meat in a fluidized bed dryer with simultaneous production of edible grade, white granulated coconut with controlled oil contents as desired for the food product end-use; (h) evaporation of the coconut water to produce a 50% coconut concentrated syrup or using it for the microbiological production of yeast or plastic materials. A patent has been filed for this process and equipment design. Most of the special components of the pilot plant equipment are being designed and fabricated in the NIST engineering shops.

21. Fluidized bed - granulated coconut: Our experiments have shown that coconut meat ground to micron size in a colloid type mill can be dried at a high speed and relatively low temperature in a fluidized bed chamber designed and fabricated in the NIST. The finely divided wet and somewhat pasty-material undergoes a granulation effect in the fluid bed at proper air velocities. Apparent air velocities above the one to two ft/sec. usually employed in a fluidized bed with fine particles are necessary. The velocities are in the liter bed rangs of four to ten ft/sec. The granulation effect eliminates fines and results in a preferred product and better operation. Present indications are that dimensionally the Fluo-Solids Dryer can be scaled down to a small size and that the temperature of the meat can be held to below 120°F, and the drying completed in a matter of minutes. Experiments indicate that dried granulated meat of good color, taste and odor can be produced. The oil pressed from this meat is of a water-white edible quality having long shelf life.

22. Creosote and charcoal briquettes from carbonization: Binders used for briquetting charcoal usually account for a substantial part of the total manufacturing cost. It has been found possible to eliminate the use of binders by combining the ground shell and husk waste and after packing this mixture into a mold under pressure, carbonizing it in a retort and recovering the creosote distillate. Proper molding pressures and carbonization conditions have been worked out to get a desirable product. The carbonizing process takes only 150 minutes at 250°C. The equipment and method of operation are relatively simple.

23. Concentrated coconut food flavor extract: Since the integrated process is directed toward diverting the coconut products into food product channels, a new quality, namely flavor, becomes highly important. The granulated coconut, since it is produced from fresh, quality coconuts at low temperature and in the shortest possible processing time, in a matter of minutes, has an excellent flavor and good keeping qualities. Development is under way to enhance the flavor when desired and to extract and eliminate the coconut odor and flavor where the bland product is preferable. Same process may be used in oil for margarine, edible oil and coco flour for some baking purposes. The extracted concentrated coconut flavor would be a high-priced product. Indications of success in this direction have been obtained through the research.

24. Sweetened coconut condensed milk: Pure "gata" or coco cream is obtained by pressing fresh grated meat. Coconut water is used for a second expression. Allow the milk from second expression to stand for one hour after which the upper layer or cream containing approximately 32% oil, 55% water, 6.57% protein and 6% carbohydrate and salt, is separated. The skimmed milk of lower layer contains approximately 1.8% protein, and the cream-skimmed milk separated from the cream by a special process of dewatering has 2.55% protein. The dewatered cream still contains about 2.3% protein. An amount of the second cream is added to the total skimmed milk to give an oil of 3.5% per cc. The mixture is vacuum distilled to a certain fraction of its original volume then 20% sugar per cc. of original milk volume is added. The process of condensation ceases when the product attains a density of 1.9. It is then placed in proper container, sealed, and pasteurized. The above product with observed long shelf life, has been analyzed to contain the following; protein 9.97%; fat 10.8%; sugar 54%; water 23.06%; ash 2.17%. The sweetened form is economically preferable, because use of sugar will also benefit the local sugar industry. This process is separated from the main integrated dry process. This food product was developed to utilize that portion of the country's total output of coconut raw materials that could not be used for the integrated fluidized bed dry process.

25. Coconut protein: The coco protein study which was first tried on experimental animals showed that the quality of coconut protein isolated from fresh mature coconuts by a process developed and employed in the NIST Food and Nutrition Research Center is comparable with casein of milk in all the essential amino acids and in promoting growth and in its percentage of body utilization. The same coconut protein when tried in formulations for infant feeding of healthy prematures showed great possibilities. Of the vegetable proteins tested, coconut protein showed better digestibility, higher biological value and a more efficient utilization of the nitrogen than cottonseed, peanut, sunflower or sesame flour. The only difference with animal protein products is that the formulation using vegetable protein has to be made at a level of 3.5 - 5.0 gm. per kg. body weight, whereas the same results can be achieved with 2.0 - 3.0 gm. per kg. of the animal protein. But the important finding in this study is the fact that coconut protein can support the normal growth of infants. Significantly, if our copra oil export volume, roughly equal to 5 1/2 billion coconuts, can be processed into 94,000 metric tons of coco protein, this big amount can greatly benefit for a whole year about 13 million protein - deficient Filipinos and other Asians, if given as a food supplement at the average intake level of 20 grams daily.2/

26. High-protein food yeast: A prolific food yeast, Torulopsis utilis (Henneberg) Lodder, rich in protein and B-vitamins can be grown in coconut

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2/ Concepcion, I., Gonzales, J. and Intengan, Carmen Ll., Preliminary Studies On the Quality of Coconut Proteins, Reprinted from the Proceedings of the Ninth Pacific Science Congress, 1957, Vol. 15 (1959)

water fortified by the addition of ammonium sulphate and trisodium phosphate, to produce a crop about ten times the original seed yeast provided that sugar concentration, aeration, pH and temperature are controlled. The sugar concentration is kept constant at slightly more than one per cent; sterile air is passed through the mash; pH is maintained at about 5.0; and the temperature of the fermenting mash is not allowed to rise more than 32°C. The yeast crop is separated by centrifuging and then dried at 40°C. The dried yeast cells contain about 50 per cent of biologically complete and palatable protein.

27. Detergents from coconut oil: Preparation of pure lauryl monoglyceride was undertaken. Lauric acid was reacted with SOC_1 and the lauryl chloride obtained. 1,2-isopropylendine-glycerol was prepared by reacting glycerine with acetone in the presence of a certain catalyst. Reaction of the lauryl chloride with the acetone-glycerol and quinoline was accomplished (after synthesis of the quinoline) and the product purified in high vacuum. Monoglyceride of 48% purity was obtained. Sulfation of the monoglyceride followed and the product neutralized. Mixture of the sulfated product with soap and binders give a fairly nice product simulating soap in texture and having washing properties comparable to commercial soaps and detergents.

Technico-Economic Interpretation and Tentative Evaluation of Results

28. Preliminary results obtained under the program indicate promising technico-economic gains. Tentative profitability estimate based on a coconut processing plant, being designed under this program, with a capacity of 100,000 nuts a day indicates a 74% return on an investment of about ₱740,000 ($370,000; conversion is ₱2 to $1).

29. The establishment of small field processing units and large central units in strategic locations in the four major coconut regions of the Philippines are contemplated to be the targets by the end of the development program. This will increase the per capita income of our rural coconut growers in line with our government's 5-year socio-economic development program. The NIST, being a government agency can not operate commercial enterprises, hence, it will transfer to private sectors the commercial scale operation of the basic plant under certain mutually agreed upon arrangements.

30. Since under present plans for the main project in which the steps of yeast production and oil extraction have been separated from the field processing unit, the equipment costs and process operations have been simplified and reduced to a point where much smaller field units than the 100,000 nut-per-day unit are possible. It fact, it now appears possible that a field unit capacity of 10,000 to 15,000 nuts/day may be economical and desirable in some locations and under certain conditions. To tie in with these smaller field units, there should be larger central processing units. The central processing unit would take the output of

products of a number of small field units and process them further when necessary for high-priced food products and for satisfying market demands and to expedite merchandising.

31. In terms of estimated economic gains to the coconut farmer, and other people involved in the industry, the diversified utilization of the fresh coconut is expected to give them a greater income than from what they are now deriving from copra. A recent survey conducted by the University of the Philippines' College of Agriculture, indicated that the average small coconut grower receives about ₱.048 per nut for his crop in the form of copra. His average crop amounts to 13,300 nuts or ₱638.40 per year. Out of this low income he pays ₱188.00 for labor and expenses, leaving him a net income of ₱450.40 per year. He is idle for 7.8 months each year. There are generally no other jobs available. 3/

32. As opposed to this existing situation, the establishment of numerous small coco field processing units, as preliminary economic studies in the NIST indicate, would raise the coco grower's income from the present ₱.048 per nut to at least ₱.07 per nut. He would also get paid for hauling the nuts to the plant. And finally there would be additional jobs in the processing plant at ₱7.00/day. Thus the grower's income would be increased two or threefold. The recovery of by-products would add another ₱23.00 per ton to the value of nuts. There being around 4,000,000 tons available per year for this type of processing, this represents a potential income of ₱92,000.00/year. The upgrading of the copra from ₱0.213 per lb. to ₱0.275 per lb. would represent an additional potential gain of ₱86,000,000/year. Setting up a central processing plant would thus create still more jobs and add greater values to the crop income by diverting the crop into higher-priced food product end-uses and further utilizing the by-products. 4/

Conclusion

33. The stability and increased income potential of the Philippine coconut industry depends to a very large degree on intensified industrial research and development work aimed at diversifying its products and by-products by complete utilization of the components of fresh nut, instead of relying on copra . To accelerate success, however, the NIST needs assistance in the form of additional up-to-date "multi-purpose" pilot plant equipment from more industrially advanced countries willing to extend help.

3/ Schuh, Charles H. Development of An Industrial Research Program in the Philippines, Quarterly Report No.3, (AID/NEC/ARF Expert Posts Project) Armor Research Foundation, Chicago and Agency for International Development, Washington, D.C. (July 2, 1962).

4/ Ibid.

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SUMMARY

Agenda Item: D.5

Philippines

INDUSTRIALIZATION OF COCONUT PRODUCTS AND BY-PRODUCTS

By CANUTO G. MANUEL, D.Sc.,
Commissioner,
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INDUSTRIALIZATION OF COCONUT PRODUCTS AND BY-PRODUCTS

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Commissioner
National Institute of Science and Technology

S U M M A R Y

1. The coconut is the premier income-producing export crop in the Philippines. In 1961, the coconut industry contributed to the national export income the total amount of $132,198,500. The Philippines is the world's biggest nut and copra producer. About 1/3 of the population (around 9 million) depend wholly or partly upon this industry for their livelihood.

2. However, the industry is presently faced with serious problems. Its status is not stable, its future is uncertain due to two factors: The recurring threat of the still unsolved "cadang-cadang"disease of coconut trees, and the increasing competition to copra and copra oil posed by synthetic detergents in foreign markets. The industry is utmost dependent only on its produce of crudely-processed and low-quality copra and copra oil. There is resultant tremendous waste in raw materials from primitive copra making. Only 20% of the whole nut is now being utilized, the 80% go to waste. The present income therefore derived from the industry represents only a small portion, about 20% of the total amount that can actually be obtained if all parts of the fresh matured nut are completely utilized and industrially developed into diversified higher-priced consumer commodities, particularly various protein-rich food products from the coco meat and water to augment the food supply of a fast growing Philippine population (3.2% increase per annum).

3. The coconut ranks foremost in potentialities for industrialization. Hence, it is in this area where top-priority application of science and technology has been considered by the National Institute of Science and Technology (NIST), the government research agency, as most prospective in terms of end-results that will tremendously enhance Philippine socio-economic progress.

4. In formulating the NIST 5-year program, which was first implemented in 1961, on the industrialization of coconut products and by-products, it was deemed of economic necessity that the coconut industry should be diversified and oriented towards a new direction of development and growth and gradually eliminate copra method. The program consists of two complimentary and simultaneous phases,

the laboratory research phase and the pilot plant developmental phase. After the second phase economically feasible project studies are passed over for private industry to commercially exploit. Long-range object: to increase marketable exports and reduce imports

5. The primary objective of the coconut industrialization program is the development of an optimum integrated process/processes for the complete utilization of the components of the coconut and the design and construction of a coconut field processing plant using fresh matured nut as the raw material. Such an integrated mechanized process combines the following major steps:

(a) husking of the coconuts;
(b) shelling the dehusked nuts;
(c) processing the fibers and coir dusts into either pulp or for construction materials;
(d) grinding the shells and other husk wastes, flash carbonizing the mixture to recover the creosote distillate and separately recovering the charcoal either for briquetting or for production of carbon black or carbon electrodes;
(e) grinding the cleaned meat to micron size;
(f) drying the ground meat in fluidized bed dryer with simultaneous production of edible grade granulated coconut with oil content controlled as desired (main product and material for various food products, including quality water-white edible oil); and
(g) evaporation of the coco water to produce a coco concentrated syrup or use the water for the microbiological production of protein-rich food yeast.

6. Economics-wise, preliminary profitability studies on the NIST integrated process, when commercialized, will increase the current per capita income of the rural coconut grower twice or thrice as much as the return from his copra making. However, while economic gains by this change of developmental approach are very promising, the major problem being met by the NIST in the prosecution of its coco program is lack of up-to-date "multi-purpose" pilot plants and facilities.

7. Selected thru a developed criteria for priority rating of specific projects based on technical feasibility, on raw materials used and end-product objectives, NIST projects on this area cover: (a) projects centered on the husk; (b) projects centered on the shell; (c) projects centered on the meat and oil (first priority field); and (d) projects centered on the coco water.

8. The specific projects, experimental processes evolved and results, and the developmental aspects of the integrated processing of coconuts are cited and described in the manuscript proper.

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Agenda Item: D.4.1

United Kingdom

THE ASSESSMENT OF THE HEALTH HAZARD TO CONSUMERS ARISING FROM THE USE OF CHEMICALS IN FOOD : PROCESSING AND PRESERVATION

By L. GOLBERG, D.Sc., D.Ph., M.A., M.B., B.Chir., F.R.I.C.

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"The assessment of the health hazard to consumers, arising from the use of chemicals in food processing and preservation"

by L. Golberg, D.Sc., D.Phil., M.A., M.B., B. Chir., F.R.I.C.

General principles regulating the addition of chemicals to food

1. To those whose problem it is to provide their people with an adequate level of nutrition, or at the very least a minimum of essential nutrients, this contribution may at first sight appear painfully academic. I can assure them that what I have to say is of concern to every minister, legislator and administrator grappling with the difficulty of making all possible use of scientific and technological advances without at the same time endangering in new, hidden and unexpected ways the health of the people he is trying to benefit.

2. In Britain, our attitude to chemicals in food and agriculture is mildly schizophrenic. A chemical which will help the farmer is welcomed with open arms, and an admirable Notification Scheme as well as other forms of administrative and scientific assistance exist to facilitate the safe introduction of a new pesticide or herbicide (1) Contrast this with the attitude enjoined by our Food and Drugs Acts which is to restrict 'so far as practicable the use in food of substances of no nutritional value' (2) Thus chemicals to help the food manufacturer are regarded as fundamentally undesirable: only an unavoidable minimum number of these can be permitted, under severely circumscribed conditions. This uncompromising attitude may serve the 'affluent societies' of the West well enough. The rest of mankind may perhaps be forgiven for adopting a less critical and more appreciative outlook on food additives of all kinds; for there can be no question regarding the benefits conferred by such additives in helping to grow more and better food, in preventing losses by spoilage and thereby facilitating nutritional improvement in difficult environments.

3. We are concerned firstly with chemicals which are added to food directly to preserve them, to prevent oxidative rancidity or other changes and generally to avoid loss by deterioration. Secondly, there are the substances introduced into food through processing or packaging, or present as residues from chemicals used to control diseases of plants or animals, or used to fight insect pests or weeds. As modern food technology develops and its benefits come to be applied on a wider and wider scale, so the need for careful supervision grows.

4. The number and variety of chemical substances involved presents

a bewildering array of potential toxic hazards against which the health of the consumer must be safeguarded. How may this best be done ? Like Beauty, Safety is a relative term. Just as perfect beauty, the absence of any blemish, may be only skin deep, so perfect safety is an illusion fostered by ignorance. Any form of food, however 'natural' it may be, is fraught with dangers to the consumer; hazards to health may arise in such traditional methods of preserving food as smoking and drying. In fact the very practice of eating involves so much risk that it ought to be abolished! Consideration of the extent of risk of any food chemical must take into account the potential benefits conferred by that substance. Acceptability of a substance can only be assessed in the light of the circumstances of its intended use. Since in any given instance the potential benefits may be considerably greater for a less developed area, so the criteria on which a decision regarding safety is based will inevitably be less rigid and inflexible than in western societies.

Toxicological basis for ensuring acceptability

5. At the present time we rely on animal tests to guide us in deciding whether a chemical is safe to use in food at any particular level (3) Such tests, though they have become ever more elaborate and expensive to perform, are still fraught with pitfalls and the assumption that the results apply to man is in many cases completely false. Even then our data apply to the individual compound before it has become part of the food. What about its interaction with the food components ? What about the possible degradative changes which it undergoes during cooking or other processing of the food ? What about the synergistic or other actions of several chemicals, either intentional or adventitious additives ? These and a host of other questions remain unanswered because this branch of toxicological science is in its infancy. Much fundamental research needs to be carried out before our present reliance on negative findings in rats and dogs can be replaced by a positive approach emphasizing the biological potential of a compound - its action on living cells and organized systems, described in terms of modern basic sciences, particularly Biochemistry, Pharmacology and Pathology.

6. It is to carry out fundamental research of this kind that the British Industrial Biological Research Association (B.I.B.R.A.) was founded in 1960 as a joint enterprise on the part of the British Government and British food, cosmetics, chemical and packaging manufacturers. There are studies already under way which are intended to provide rapid and efficient methods of preliminary toxicity screening for new compounds, thus helping to reduce the cost and time involved in the development of novel and potentially valuable agents. Such steps are all-important if the increasing difficulties and complexities are not to bar the way to

technological progress and ultimately to stifle research into new food additives. Other aspects of B.I.B.R.A.'s programme are concerned with liver function and its repercussions on the results of toxicity testing; with the nature and quantity of dietary fat, the storage of dietary chemicals in body fat and the effects of malnutrition, infectious and other disease processes on the hazard presented by such chemicals. The general emphasis in the past has been on tests carried out on so-called 'normal animals', with little concern for the influence of diet or environment, which can profoundly affect the outcome of tests. B.I.B.R.A. feels that the time has come for a 'new look' in the whole field of food additive toxicology and the interests of the wider world outside, especially in tropical conditions, are very much in our minds in planning this new approach.

The practical approach to safety evaluation

7. Faced with the practical problem of deciding whether a particular food additive or pesticide is acceptable when used in a specified manner, the legislator and his technical advisers have inevitably to fall back on simple rules which are readily applied. He is aware of their shortcomings but, until the current advances in basic sciences provide him with something more satisfactory, the present-day procedures must be used. It is important, however, to maintain a flexible attitude, to be ready to accept alternative approaches, and above all to mould the experimental method to the individual problem rather than try to fit each and every investigation into the same rigid petrified pattern.

8. With these provisos it can be confidently stated that the 90-day chronic test, carried out in two species of laboratory animal, will long remain the keystone of safety studies. The thoroughness with which this test is planned and conducted, the appropriate choice of levels of administration of the test substance, and the knowledge and experience brought to bear on the interpretation of the results, determine the value of the test in relation to the whole issue of safety evaluation. With a compound which is not too distantly related to accepted food additives, the 90-day test will reveal all, or practically all, that is forthcoming from an elaborate study conducted over a period of 2 years. The 90-day study avoids the complications introduced by ageing changes in rats and mice. On the other hand it provides little information on possible carcinogenic hazard. This latter issue is too vast to be discussed here (4,5,6) Nevertheless its importance to emergent countries is considerable, since lack of care and foresight to-day may only reveal itself in disastrous consequences twenty years from now. A possible manifestation of this sort of hazard is the enormously increased incidence of oesophageal cancer among the Bantu of South Africa,

particularly in the Transkei (7) Suffice it to say that the development of an accelerated test for the assessment of carcinogenicity is also one of B.I.B.R.A.'s research objectives.

9. The extrapolation of animal testing results to man is greatly facilitated by knowledge of the principal human metabolic pathways of a new compound. This then is the preferred approach, rather than longer and longer tests in more and more animals. Provided an animal species is found whose metabolism of the test substance is similar to man's, safety evaluation in this species is far more satisfactory than random testing. This is the principle adopted by B.I.B.R.A. in conducting its own routine testing programme.

Provision for future needs

10. I have tried to give some indication of the scientific complexity of the subject, to convey an impression of the interwoven pattern of scientific disciplines brought to bear on it, and of the unavoidable need for wide experience in many scientific fields in order to assess the overall significance of toxicological findings.

11. How is an emergent nation to attempt to deal with food additives, faced as it is with a multitude of far more vital problems ? One way would be to imitate what is done in the field of drugs, where the British or U.S. Pharmacopoeias are used as a yardstick. Unfortunately some almost insuperable problems arise. For instance, no two permitted lists of food additives bear even a close resemblance to one another. Quite often the experts of one country disagree with those of another. Adoption of one country's list places exporters in other countries at a considerable disadvantage and may act to the detriment of a young nation wishing to increase food supplies, to improve the general availability of good food, and to export some of its primary produce.

12. What is needed is: firstly, information, to keep the country's scientists in touch with world developments in the legislative and scientific spheres; secondly, a source of expert advice to which scientists and administrators can have ready and speedy access without the need for formality, protocol or red tape; and thirdly, testing and research facilities with first-class personnel embracing all the various disciplines involved in safety evaluation. In order to be adequate such services must include an irreducible minimum of facilities of considerable size, complexity and cost. It seems pointless that each country should duplicate all these, even if it was within its power to do so. Until such time as an international

organization can provide all these essential services, the British Industrial Biological Research Association is ready to do all it can to undertake this task. As an independent non-profit making organization, we are anxious to extend our membership overseas among the less developed areas where our efforts can bear so much fruit in terms of human welfare.

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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item : D. 4. 1

United Kingdom

THE ASSESSMENT OF THE HEALTH HAZARD TO CONSUMERS ARISING FROM THE USE OF CHEMICALS IN FOOD : PROCESSING AND PRESERVATION

By L. GOLBERG,
D. Sc., D. Phil., M. A., M. B.,
B. Chir., F. R. I. C.

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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SUMMARY

"The assessment of the health hazard to consumers, arising from the use of chemicals in food processing and preservation"

by L. Golberg, D.Sc., D.Phil, M.A., M.B., B.Chir., F.R.I.C.

1. The presence of direct additives and adventitious chemical residues in food is important to everyone concerned with making full use of scientific and technological advances without at the same time endangering the health of the people.

2. In Britain, procedures exist to facilitate the safe introduction of new agricultural chemicals. Chemicals to help the food manufacturer or distributor, however, are only permitted under severely circumscribed conditions. In the less developed areas the benefits conferred by food additives in preventing losses by spoilage and thereby facilitating nutritional improvement in difficult environments justify the adoption of a less uncompromising attitude. Even in such countries however there arises an increasing need for careful supervision, especially in connection with substances introduced into food as processing aids, migrating from packaging material or remaining as residues from pesticides or herbicides.

3. The toxicological basis for ensuring acceptability of any food chemical rests largely on animal tests which have become ever more elaborate and expensive to perform. In spite of this, they leave many questions open to doubt. Extensive fundamental research is required in order to replace our present reliance on negative findings in animals by a positive approach emphasizing the biological potential of a compound - its action on living cells and organized systems, described in terms of modern basic sciences, particularly Biochemistry, Pharmacology and Pathology.

4. It was partly for this purpose that the British Industrial Biological Research Association (B.I.B.R.A.) was set up in 1960 jointly by the British Government and food, chemical, cosmetics and packaging manufacturers. Studies are already under way which are intended to provide rapid and efficient methods of preliminary toxicity screening for new compounds. In addition, other aspects of B.I.B.R.A.'s programme are concerned with dietary chemicals in body fat and the effects of malnutrition, and infectious and other disease

processes on the hazard presented by such chemicals. B.I.B.R.A. feels that insufficient attention has been paid in the past to environmental influences and that a new approach must take these factors into account.

The practical approach to safety evaluation

5. Faced with the practical problem of deciding whether a particular food additive or pesticide is acceptable when used in a specified manner, the legislator and his technical advisers have inevitably to fall back on simple rules which are readily applied.

6. With certain provisos it can be confidently stated that the 90-day chronic test, carried out in two species of laboratory animal, will long remain the keystone of safety studies. With a compound which is not too distantly related to accepted food additives, a thorough 90-day test conducted by skilful workers will reveal all, or practically all, that is forthcoming from a 2-year study. The detection of possible carcinogenicity still remains a serious problem and the development of an accelerated test for this purpose is also one of B.I.B.R.A.'s research objectives.

7. The extrapolation of animal testing results to man is greatly facilitated by knowledge of the principal human metabolic pathways of the new compound. Provided an animal species is found whose metabolism of the test substance is similar to man's, safety evaluation in this species is far more satisfactory than random testing.

Provision for future needs

8. How is an emergent nation to attempt to deal with food additives ? One way would be to imitate what is done in the field of drugs, where the British or U.S. Pharmacopoeias are used as a yardstick. For several reasons this course if often impracticable.

9. What is needed is: information, to keep the country's scientists is touch with world developments in the legislative and scientific spheres; and testing and research facilities with first-class personnel embracing all the various disciplines involved in safety evaluation. Until such time as an international organization exists which can fulfil all these functions, the British Industrial Biological Research Association, as an independent non- rofit making body, is ready to undertake this task for the benefit of the less developed areas.

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Agenda Item: D.11.1

United Kingdom

THE TECHNICAL FACTORS WHICH DETERMINE THE CHOICE OF RAW MATERIAL PROCESS PRODUCT (NITROGENOUS, PHOSPHATIC OR COMPOUND FERTILISER) AND LOCATION OF PLANT

By A.J. PAYNE, Ph.D., M.I. Chem. E.

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The Technical Factors which Determine the Choice of Raw Material, Process Product (Nitrogenous, phosphatic or Compound Fertiliser), and Location of Plant.

Author: A.J. Payne, Ph.D., M.I.Chem.E.

1. The necessity for higher and more efficient food production, particularly in the under-developed countries is self-evident. The use of chemical fertilisers is essential to obtain higher rates of production and for the efficient utilisation of the land.

2. After accepting in principle that a particular region may justify having a fertiliser plant, a number of inter-related factors must be considered in detail before a decision can be made to proceed with the project. These principal factors are -

Type of product to be manufactured

Scale of operation to be used

Raw materials to be utilised and Process Selection

Location of the plant

3. Selection of Product

(a) Before examining in detail the factors affecting the type of product or products to be manufactured, it is of interest to consider the present pattern of fertiliser production, and the changes that have occurred during the past two decades. Figure I shows the development of world fertiliser production between 1954 and 1960 on the basis of nitrogen, phosphorous (as P_2O_5) and potash (as K_2O). Table 1 shows the relative contribution of different types of nitrogenous fertilisers between 1951 and 1960. The general indication given by the figures and by the trends described in current literature is for the production of fertilisers of higher concentration of nitrogen and phosphorous and for the nitrogen consumption to have increased more than that for the phosphorous and potassium. The reason for the predominance of phosphatic fertilisers previously is probably due to the early establishment of the superphosphate manufacturing industry and to the relative simplicity and low capital cost of the plant compared with ammonia synthesis plant.

(b) The nitrogenous fertilisers which have greatly increased in production are urea and ammonium nitrate; fertilisers containing both nitrogen and phosphrus such as mon and di-ammonium phosphates

are also showing increasing popularity. Compound fertilisers based on ammonium nitrate, ammonium phosphate or urea and also containing potash have become increasingly in demand by farmers.

(c) Obviously agronomical considerations must be foremost in selecting the fertiliser to be used. Field trials must be carried out before any plant is built to ensure that the most suitable fertiliser is selected and that the farmers can be convinced of the advantages of using that material. Climatic conditions must also influence the type of fertiliser to be made and its required physical characteristics. In humid climates it would obviously be unwise to manufacture products which would absorb moisture and become difficult to handle. While it is possible to air-condition storage silos on site, it must be envisaged that materials may be stored in bulk at local distribution centres where air-conditioning is not a practicable proposition. Various techniques can be adopted to minimise the effect of climatic conditions. Products such as compound fertilisers, superphosphate, ammonium nitrate, etc., can be produced in a granular form which is more resistant to caking, and they may also be oiled and coated. The production of a spheroidal product by prilling is another technique which is used, particularly for urea and ammonium nitrate.

(d) The basic approach to the selection of a nitrogenous or phosphatic fertiliser product should be by comparing the cost per unit of nitrogen and P_2O_5 in various products and choosing the one with the minimum cost. Unfortunately, such an approach is rarely of as much value as it might appear since other factors such as the concentration of the nutrients greatly affect the cost of transport per unit of nutrient, and also its acceptability to the farmer. Such a comparison is easier when comparing straight nitrogenous or phosphatic fertilisers such as ammonium nitrate against urea, or single superphosphate against triple super phosphate. Again, however, the premium which should be allowed for the higher concentration is not easy to assess. A further advantage, for example, of higher concentration material such as di-ammonium phosphate, urea and triple superphosphate is that they may be considered as intermediate raw materials that may be locally mixed or compounded by smaller-scale manufacturers.

(e) An interesting recent development is the manufacture of slow acting fertilisers where the rate of release of nitrogen is controlled. An example of this type of material is an urea-formaldehyde fertiliser now being manufactured in France.

(f) Table 2 shows comparative production costs per ton P_2O_5 for single and triple superphosphate on the basis of the production of 45 tons/day P_2O_5. It will be seen that single superphosphate is cheaper per unit P_2O_5 to produce than triple superphosphate. However, when rail transport of the product is included, triple will be cheaper per unit nutrient than single when distances of 250 miles or more are involved.

(g) For straight nitrogenous fertilisers production costshave been compared on the basis of 250 tons of nitrogen per day for the manufacture of ammonium sulphate, ammonium nitrate and urea. For the ammonium sulphate plant, it is assumed that a sulphur burning acid plant is included. From Table 3 it will be seen that the production costs per ton N is lowest for urea, followed by that for

lime ammonium nitrate and with the cost per ton N being the highest for ammonium sulphate.

(h) It must be emphasised that these production costs are based on hypothetical circumstances and that they will in practice vary considerably depending upon individual circumstances.

4. Scale of Production

(a) It can be seen from Table 2 that raw materials costs form the largest element in the production costs of straight phosphatic fertilisers. The economics that can be achieved by larger scale operation are therefore limited and are due mainly to savings on operating labour and supervision.

(b) There is little limitation upon the maximum size of unit. Grinding mills can be obtained with unit capacities of from 15 to 30 tons/hr depending upon the characteristics of the rock. Reaction dens can be obtained with capacities ranging from 6 to 70 tons/hr superphosphate, their throughput on triple superphosphate being about half that on single superphosphate. For phosphoric acid plants it is possible to obtain filters with effective areas up to 56 square metres, equivalent to a capacity of 250/300 tons per day expressed as phosphorus pentoxide.

(c) Figure II shows the effect of the scale of production upon the total erected capital cost of ammonia plants. For the purpose of this comparison it has been assumed that the synthesis gas is derived by the partial oxidation of petroleum hydrocarbons. Apart from the obvious advantages in capital and operating costs in building very large units, the use of computers for controlling process variables becomes of economic interest for large units.

5. Raw Materials to be Utilised and Process Selection

(a) For the production of synthetic ammonia, it is obvious that the processes producing the synthesis gas mixture of nitrogen and hydrogen cannot be considered without reference to the source of the hydrogen.

(b) Prior to World War II coal and coke was the hydrogen source for about 80% of world's production of synthetic ammonia. The development of reforming and partial oxidation processes utilising petroleum hydrocarbons has reduced this figure to about 40%. Catalytic reforming processes offer the most economical route where a "light" hydrocarbon feedstock is available, ranging from methane to naphthes with boiling points up to 200°C. Plants of this type are in operation at pressures of up to 20 atmospheres. The disadvantages of this type of process are the limitations regarding the feedstock which can be used and also the sensitivity of the catalyst to impurities in the feedstock, particularly sulphur. The production of synthesis gas by the partial oxidation of petroleum hydrocarbons, as typified by the Texaco and Shell Processes has found wide acceptance. The advantage of this type of process is its ability to use feedstocks ranging from methane to heavy fuel oil. The main disadvantage is the need for an air separation plant to provide oxygen which increases the capital and operating costs compared with the reforming process. The choice between reforming and partial oxidation must largely depend upon the

relative price and long-term availability of possible petroleum feedstocks. Where cheap natural gas is available, the use of pressure reforming processes can lead to the production of ammonia at a very economical price.

(c) Phosphate rock is the raw material for phosphatic fertilisers and the principal sources are in the U.S.A., U.S.S.R., Tunisia, Morocco, Algeria and the Pacific Island of Nauru. The phosphate rock is processed into single superphosphate by the action of sulphuric acid, into triple superphosphate by the action of phosphoric acid, or the reaction of phosphoric acid with ammonia to form ammonium phosphates. Phosphoric acid for fertiliser use is normally produced by the "wet process" involving the action of sulphuric acid on the rock and the subsequent removal of the calcium sulphate by filtration. An alternative route to phosphoric acid is by reacting phosphate rock and coke in an electric furnace to produce elemental phosphorus which is subsequently converted to phosphoric acid. The "wet process" normally offers the most economical route to fertiliser grade acid. The production cost of phosphatic fertilisers is chiefly dependent upon the cost of rock and of sulphuric acid. For example, in the production of phosphoric acid, approximately 40% of the cost is accountable to phosphate rock and only slightly less to sulphuric acid. For European producers more than half the cost of phosphate rock is due to transport charges.

(d) The advantage of locating plant at the rock deposits or at least close to harbours is obvious. Future development may also be in the field of transporting more concentrated forms of phosphorus which can be utilised by fertiliser manufacturers than phosphate rock. Potassium Metaphosphate, comprising 60% P_2O_5 and 40% K_2O is an example of the type of concentrated material which might well be used as an intermediate in the production of complete fertilisers.

6. Location of Plant

(a) Obviously the first consideration in locating a fertiliser plant is the easy access to raw materials and adequate transport facilities for distributing the product from the works. These facilities must be adequate even at the peak periods during the fertiliser season. The economic advantages to be gained by locating the works at the source of raw materials has been illustrated by the phosphatic fertiliser installations under construction in Morocco and the project for the production of ammonia from cheap natural gas in Trinidad. This ammonia will be shipped in refrigerated tankers to consumers throughout the world. If the sea transport of liquid ammonia is proved to be feasible then there will be strong economic incentives to manufacture ammonia from the plentiful natural gas available in North Africa and the Middle East.

(b) The availability of water for process processes and for cooling water make-up is an obvious necessity as is also an electrical supply. Interruption to the electrical supply will gravely handicap the operation of the works and if this circumstance can arise, due say to the effect of lightning on overhead lines, it is desirable to provide a second incoming supply. While sea water can supply much of the cooling water requirements for plants located on a coast it

is still necessary for fresh water cooling circuits to be used in those items of equipment, such as compressors, where the water flow could be impeded by rust or other deposits. The use of sea water for cooling compared with fresh water increases equipment costs due to the need for special materials of construction in place of mild steel.

(c) The disposal of effluents may also be an important factor in considering site location. Gypsum (calcium sulphate) is a by-product of the manufacture of phosphoric acid by the "wet process" and presents a disposal problem. The normal way of disposing of the gypsum is to pump it as a slurry into the sea or a river. It may be found possible to utilise the gypsum for the manufacture of plaster board or for the production of ammonium sulphate, although this latter use will depend upon the relative economics of sulphuric acid manufacture. The gaseous effluents produced in fertiliser plants do not normally present difficult problems and established methods exist for dealing with them.

7. Conclusion

It will be appreciated that the various problems related to the establishment of a fertiliser factory have necessarily been dealt with in broad outline only. Nevertheless, it is hoped that enough has been said to demonstrate that a very careful survey of the whole field is necessary before even an outline scheme can be prepared. It is hoped that, brief though it is, this paper will serve to stimulate discussion of the very large and important topics covered by its title, and so facilitate the approach to the concrete problems of increasing fertiliser production.

TABLE 1

RELATIVE CONTRIBUTIONS OF DIFFERENT KINDS OF NITROGENOUS FERTILISERS TO WORLD OUTPUT

Kind of Fertiliser	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60
			Per cent			
Ammonium Sulphate	31	32	30	29	28	26
Ammonium Nitrates	27	27	27	27	25	26
Sodium Nitrate	5	4	4	4	4	3
Calcium Nitrate	6	5	5	5	5	5
Calcium Cynamide	6	4	4	4	3	3
Other forms						
"Solids"	7	10	12	13	15	16
"Solutions"	17	17	17	17	19	20
Organic Materials	1	1	1	1	1	1

(1) Fertilisers - An Annual Review of World Production, Consumption & Trade - F.A.O.

TABLE 2

COMPARATIVE PRODUCTION COSTS FOR SINGLE AND TRIPLE SUPERPHOSPHATE

Basis : 45 tons/day P_2O_5

	Single Superphosphate (18/22% P_2O_5)		Triple Superphosphate (45/45% P_2O_5)	
Total installed cost	£465,000		£700,000	
	£ Cost per ton	£ Cost per ton P_2O_5	£ Cost per ton	£ Cost per ton P_2O_5
Raw Materials	6.35	31.75	13.40	29.8
Utilities	1.10	5.50	8.70	19.4
Depreciation	0.54	2.70	1.86	4.1
Labour and Supervision	0.44	2.20	1.20	2.7
Maintenance	0.16	0.80	0.53	1.2
Overheads	0.89	4.45	2.40	5.3
	9.48	47.40	28.09	62.5

NOTES

(1) No allowance for interest has been made.

(2) A depreciation period of 10 years has been allowed for process plant and 20 years for buildings, stores, etc.

(3) Overheads have been assumed as 200% on labour and supervision.

(4) It has been assumed that all the product is bagged.

TABLE 3

COMPARATIVE PRODUCTION COSTS FOR VARIOUS NITROGENOUS FERTILISERS Basis 250 tons/day N.

	Ammonium Sulphate		Lime Ammonium Nitrate		Area	
Total installed cost	£5,350,000		£7,150,000		£6,600,000	
	£ Cost per ton	£ Cost per ton N	£ Cost per ton	£ Cost per ton N	£ Cost per ton	£ Cost per ton N
Raw Materials	4.7	22.6	2.50	12.2	3.85	8.3
Utilities	1.3	6.1	1.47	7.2	3.24	7.0
Depreciation	1.2	5.6	1.60	7.8	3.26	7.1
Labour and Supervision	0.17	0.8	0.19	0.9	0.42	0.9
Maintenance	0.34	1.6	0.44	2.2	0.93	2.0
Overheads	0.34	1.6	0.38	1.9	0.83	1.7
	8.05	38.3	6.58	32.2	12.53	27.0

NOTES

(1) No allowance for interest has been made.

(2) A depreciation period of 10 years has been assumed for process plant and 20 years for buildings, roads, off-site installations etc.

(3) Overheads have been assumed as 200% on labour and supervision.

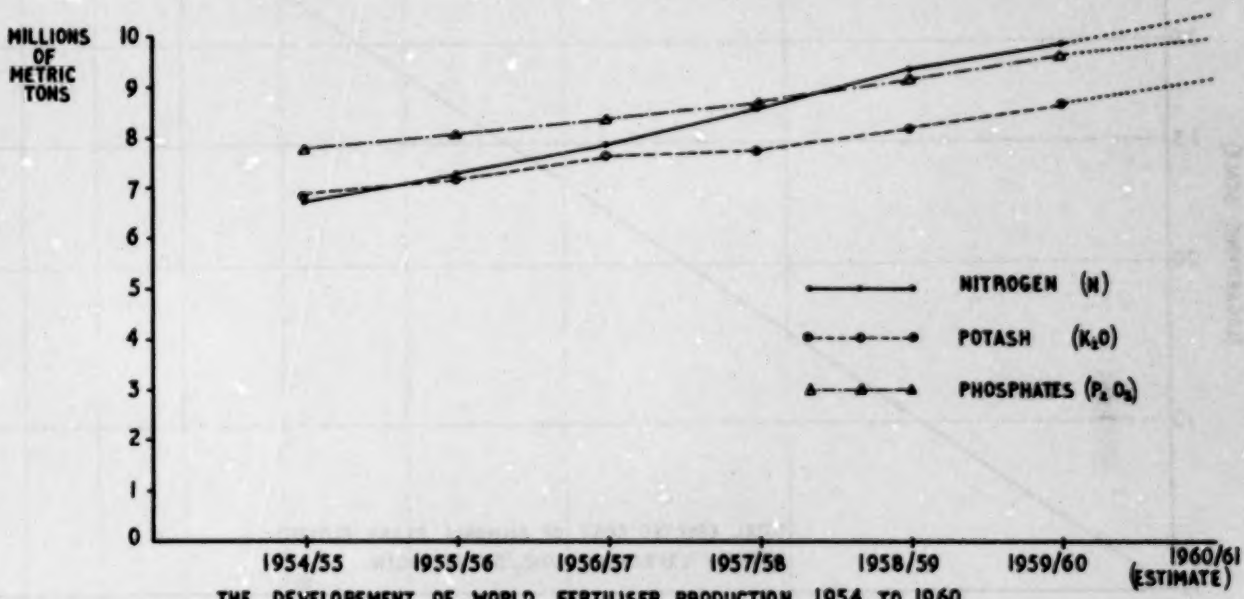
(4) For lime ammonium nitrate plant it has been assumed that a product containing 20.5% N is being manufactured.

(5) It has been assumed that half of the output for each product is being bagged and the remainder being despatched in bulk.

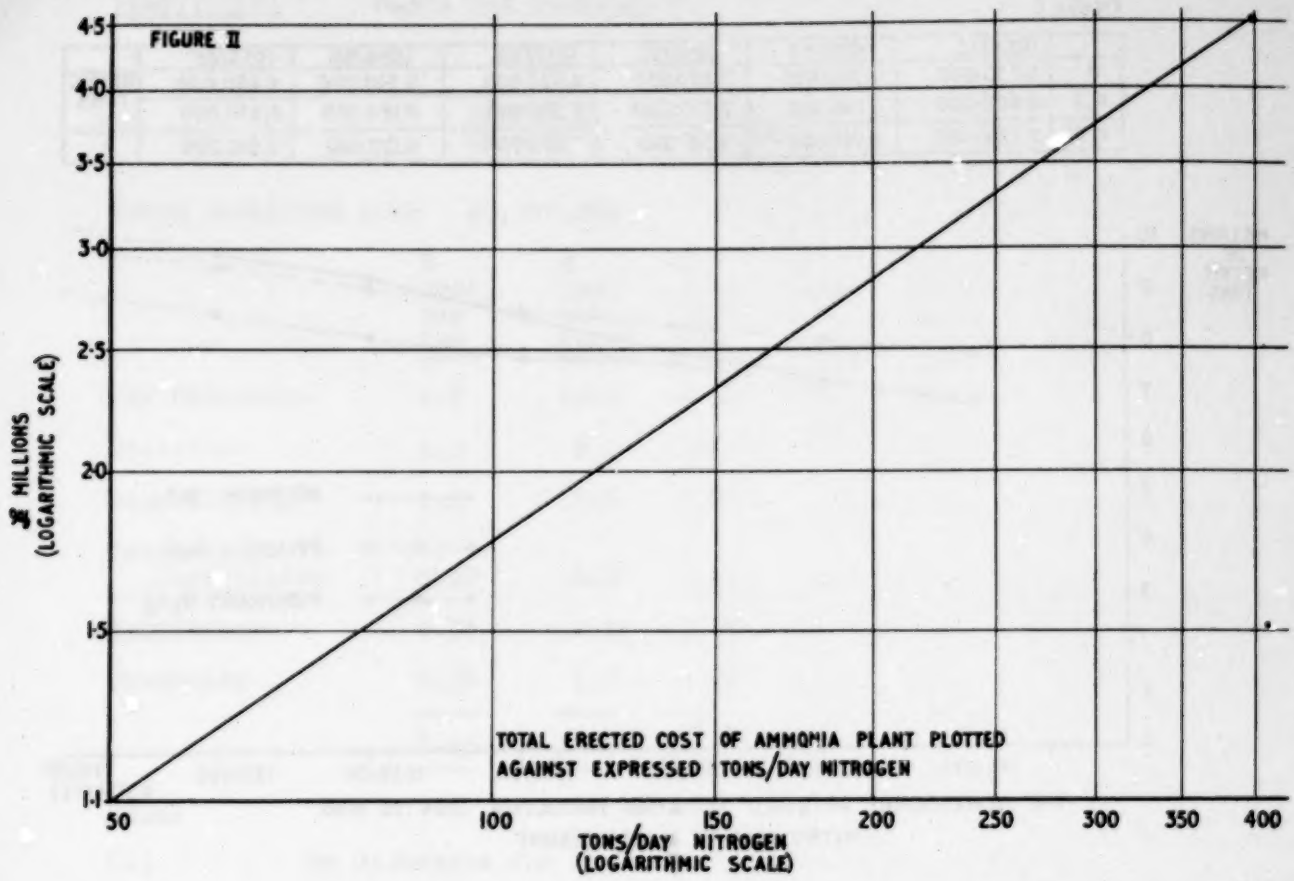
(6) The partial oxidation under pressure of heavy fuel oil has been assumed as the means of production of synthesis gas.

FIGURE I

	1954/55	1956/56	1956/57	1957/58	1958/59	1959/60	
N.	6,730,000	7,200,000	7,850,000	8,570,000	9,390,000	9,920,000	METRIC TONS
K_2O	6,800,000	7,140,000	7,610,000	7,710,000	8,160,000	8,630,000	"
P_2O_5	7,720,000	8,030,000	8,310,000	8,630,000	9,130,000	9,650,000	"



THE DEVELOPEMENT OF WORLD FERTILISER PRODUCTION 1954 TO 1960
METRIC TONS OF PLANT NUTRIENT



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Agenda Item: D.11.1. United Kingdom

THE TECHNICAL FACTORS WHICH DETERMINE THE CHOICE OF RAW MATERIAL, PROCESS PRODUCT (NITROGENOUS, PHOSPHATIC OR COMPOUND FERTILISER) AND LOCATION OF PLANT

By A. J. PAYNE
Ph.D., M.I. Chem. E.

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SUMMARY of Paper Entitled "The Technical Factors which Determine the Choice of Raw Material, Process Product (Nitrogenous, Phosphatic or Compound Fertiliser) and Location of Plant", by A. J. Payne, Ph.D., M.I.Chem.E.

Agenda Item D.11.1.

The paper directs attention to the importance of higher and more efficient food production and the corresponding need for chemical fertilisers.

Before discussing the various factors which influence the selection of a fertiliser for manufacture in any given location, a review of world fertiliser statistics is presented, and the change in utilisation of fertilisers having nitrogen, phosphorous and potash as base is shown graphically for the period 1954-1960. The reasons for the changes are briefly considered.

The paper stresses that agronomical considerations are most important in selecting fertiliser types; field trials are normally essential. The influence of climate on manufacture and use are considered.

The difficulty in arriving at realistic cost comparisons is demonstrated and the data which must be taken into account are indicated.

Production costs and their variation with size of plant are then considered, for phosphates and nitrogenous fertilisers.

Raw materials are discussed, including the change in the source of hydrogen for synthetic ammonia production. The increasing use of natural gas or petroleum products as a source of hydrogen and the type of process to be used for this are considered.

Sources of phosphate rock and the processes used for production of phosphate fertilisers are described and the economic background briefly considered.

The influence of raw material location, transport facilities, availability of water and electricity and other factors on the choice of site for a plant are indicated and the paper concludes by stressing the importance of a thorough investigation of all relevant data before any decision on plant, site or material is taken.

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CONFÉRENCE DES NATIONS UNIES
SUR L'APPLICATION DE LA SCIENCE ET DE LA TECHNIQUE
DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES

Point de l'ordre du jour : D.3.3

France

LA NORMALISATION INDUSTRIELLE

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Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

2. Les mémoires choisis pour être présentés en séance spéciale pourront être obtenus à la Conférence dans l'une seulement de ces langues officielles.

3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

4. Préalablement à la Conférence, les mémoires et les résumés ne feront pas l'objet d'une distribution générale mais d'un tirage restreint destiné aux délégations des gouvernements et autres participants officiels. La publication et la distribution générale des actes de la Conférence s'effectueront conformément aux règles et pratiques agréées par le Comité des publications des Nations Unies.

I - Normalisation et industrialisation

Les pays en voie de développement doivent trouver dans la normalisation un moyen de passer plus rapidement du stade de la production artisanale et de l'importation anarchique à celui de l'industrialisation, de la rationalisation des produits agricoles, enfin de l'organisation économique en général.

Le présent exposé s'attachera plus particulièrement aux applications du principe général de normalisation aux activités industrielles.

Pour le grand public, le mot de normalisation évoque l'idée de travail en série ou d'interchangeabilité : c'est souvent vrai, mais la normalisation est aussi beaucoup d'autres choses. L'interchangeabilité n'en est dans bien des cas qu'une conséquence secondaire, et aucune définition simple ne peut donner une évocation complète de la normalisation et de son intérêt, d'autant plus que la normalisation doit s'exercer partout où il y a un besoin d'ordre et de discipline.

Les normes fondamentales et générales

Pour éviter toute confusion dans les échanges d'idées, soit entre les personnes du même pays, soit entre les experts des pays industrialisés et les habitants des régions peu développées, il importe de fixer la terminologie, d'unifier les dessins techniques, et d'utiliser des unités de mesure cohérentes.

La terminologie paraît parfois une question d'intérêt secondaire, les spécialistes d'une branche technique ayant le plus souvent le moyen de rectifier les traductions impropres de certains termes faites, incidemment, par des interprètes non spécialisés.

Mais le problème dans les régions peu développées est tout différent car, le plus souvent, le vocabulaire de la région peu développée considérée ne comporte pas tous les termes nécessaires pour certaines branches techniques : seules les définitions correctes permettent la création de termes nouveaux ou l'emploi de périphrases, en évitant la traduction littérale de termes d'origine étrangère qui étaient pris dans un sens trop figuré.

Les dessins techniques dans presque toute industrie, constituent un des moyens d'expression les plus pratiques. Ce moyen, d'un intérêt incontestable entre personnes parlant la même langue, devient indispensable dans les relations internationales, car il est beaucoup plus indépendant du langage que les textes.

Il importe cependant que les conventions du dessin apprises par les uns et les autres soient les mêmes, et que ces conventions soient suffisamment complètes sans être trop complexes. Ainsi le dessinateur comme le lecteur des régions peu développées les apprendra facilement, plus facilement qu'une langue nouvelle avec sa grammaire et sa syntaxe.

Il faut enfin unifier les unités de mesure et en donner d'une façon claire et compréhensible les définitions.

Déjà, dans les pays industrialisés, certaines difficultés se produisent du fait de la dualité du système métrique et du système anglo-saxon basé sur l'inch et la livre (systèmes pour lesquels des facteurs de conversion sont établis et connus). En outre fréquemment, dans les régions peu développées, d'autres mesures sont d'un emploi local et il importe d'introduire pour la facilité des relations un système cohérent et facile à enseigner d'unités de mesure pour toutes les unités employées dans les domaines de la mécanique, de l'électricité, de l'optique principalement.

D'une façon générale, dans tout pays, la normalisation peut utilement - et légitimement - se présenter comme une porte d'entrée à ce que l'on pourrait appeler la culture générale technique : l'intérêt d'une telle conception de la normalisation est double : d'une part, elle répond à des besoins immédiats de l'industrie et de l'économie en général; d'autre part, acceptée par l'enseignement, elle associe dans l'esprit des futurs cadres du pays la notion de normalisation et la notion d'ordre technique, préparant aussi la voie à des générations formées à ces disciplines.

Cette orientation de la normalisation vers l'avenir impose de façon particulièrement nécessaire l'adoption par les instituts de normalisation des bases métrologiques les plus modernes, - et en particulier des unités du système international dit S.I. de la Conférence Générale des Poids et Mesures.

Normalisation des Biens de consommation

Pour les objets relevant des fabrications mécaniques d'usage courant : ustensiles ménagers (casseroles ...) petit outillage agricole (bêches, scies ...) petit outillage mécanique (marteaux, pinces), la normalisation est essentielle pour satisfaire les besoins des régions peu développées tant au stade de l'achat à un pays industrialisé qu'au stade de l'industrialisation en vue de la fabrication dans le pays lui-même.

En effet, lorsqu'il s'agit d'introduire dans les régions peu développées un outillage permettant d'améliorer le rendement du travail humain et de le rendre plus efficace, il importe de mettre en mains des travailleurs un outillage bien adapté et de bonne qualité. Pour guider ce choix, les normes existantes dans les pays industrialisés permettent de trouver une première sélection de matériel dans laquelle on peut choisir un nombre limité de dimensions répondant aux besoins particuliers du travail à effectuer dans le pays.

Pour les autres biens de consommation de nature industrielle : ameublement, articles textiles, on peut faire valoir des considérations analogues,

Les normes de qualité donnent la possibilité de retrouver la nature et la valeur des caractéristiques permettant un bon emploi des articles et d'exiger celles-ci des fournisseurs.

Lorsqu'a pu être réalisée une unification sur le plan de la normalisation internationale, une comparaison des produits des pays industrialisés qui ont aligné leurs normes devient extrêmement facile et les meilleurs prix peuvent être obtenus pour des articles équivalents.

Ainsi les normes dimensionnelles et les normes de qualité permettent de réaliser les approvisionnements à des conditions avantageuses avec un minimum de stocks et d'éviter surtout les frais nécessités par l'achat et le stockage de produits qui ne seraient pas immédiatement nécessaires à l'approvisionnement.

Un autre problème est celui de la création d'ateliers qui permettent, d'une part de donner du travail à ceux qui n'en trouvent pas, et, d'autre part, de réduire l'importance des achats à l'étranger. Si l'extension d'ateliers artisanaux existant dans les diverses régions du pays est souhaitable, il est rarement avantageux de conserver des méthodes de fabrication trop primitives, et de maintenir des modèles anciens qui n'ont pas bénéficié d'études scientifiques pour l'amélioration de leur forme et de leur qualité.

Il est préférable d'envisager l'implantation d'usines pour la fabrication d'un nombre extrêmement limité d'articles choisis par sélection dans les normes existantes, ces articles ayant été reconnus comme étant les plus demandés. Ceci permet de donner stisfaction à un pourcentage important des besoins en réalisant des fabrications à des conditions intéressantes de prix, sans disperser les efforts sur des produits trop disparates.

Normalisation des Biens d'équipement

Dans le domaine des biens d'équipement, les problèmes qui se posent pour les régions peu développées sont tout différents, mais les conclusions sur l'intérêt de la normalisation sont très comparables à celles que l'on rencontre pour les biens de consommation.

Qu'il s'agisse de machines-outils pour le travail du métal ou pour le travail du bois, de machines pour l'industrie textile, de gros matériel de mines, de travaux publics ou de sidérurgie, etc..., il est incontestable qu'il est intéressant de réduire le nombre de types de machines de façon à faciliter la formation du personnel qui doit les faire fonctionner, et leur entretien.

Mais, si la normalisation des machines complètes est assez rare, la normalisation des éléments de machines est très développée, ce qui permet leur remplacement non seulement pour les machines d'un même pays fournisseur, mais encore pour celles en provenance de pays différents lorsque l'unification a été faite sur le plan international de l'ISO.

La normalisation la plus indispensable est d'ailleurs celle qui permet l'emploi d'un outillage normalisé (outils de tour, forets, tarauds, fraises, etc...).

Naturellement, s'il s'agit d'usines montées de toutes pièces par appel à la logistique technique étrangère (engineering) la référence aux normes du pays d'origine est une garantie désirable, toutes les fois que cette garantie ne peut être trouvée dans une norme internationale.

La notion d'équipement s'étendra aux techniques de mise en valeur : unités, instruments et méthodes de mesure. On appliquera par exemple aux irrigations les méthodes ISO de mesure du débit des fluides ; on évitera d'introduire dans les laboratoires et services de contrôle de qualité d'un pays métrique des instruments de mesure ou des tables de constantes en unités non métriques ; on modernisera même les données métriques en vigueur pour les mettre en accord avec le système S.I. cité plus haut.

Normalisation et Sécurité

La recherche de la sécurité en général, et particulièrement celle de l'emploi des machines, est généralement considérée comme liée à la normalisation. C'est un domaine important, et il l'est encore plus pour les pays peu développés.

Il est en effet à noter que, pour arriver à un même but et assurer la sécurité d'emploi d'appareils qui peuvent être ou devenir dangereux pour le personnel qui en assure le service, les modes de calcul imposés et les dispositifs de protection exigés ne sont pas les mêmes dans les divers pays. Peu importe d'ailleurs que ces diverses exigences résultent dans chaque pays de normes ou de règlements administratifs.

Mais les constructeurs qui, normalement, étudient leurs machines en se basant sur les dispositions imposées à leur propre pays, présentent des matériels dont la comparaison est difficile du point de vue sécurité ; ils ne peuvent faire économiquement pour chaque pays un matériel différent, alors que la protection de la santé ou de la vie d'un travailleur devrait avoir les mêmes exigences partout.

L'unification sur le plan international de ces prescriptions de sécurité présente donc un intérêt considérable et un très grand nombre de comités de l'ISO s'attachent à ces questions. Cette unification porte à la fois sur les dimensions de certains éléments et sur la qualité des matériaux employés.

On peut citer comme exemple d'études en cours actuellement, les chaudières, les appareils de levage, le matériel de mines et tout récemment un nouveau comité technique de l'ISO a été créé pour étudier les équipements assurant la protection individuelle des travailleurs.

L'unification internationale des prescriptions de sécurité que cherche à réaliser l'ISO en liaison avec le BIT permettra aux Gouvernements des régions peu développées de rédiger, en se basant sur ces Recommandations des prescriptions auxquelles répondront sans difficulté les pays industrialisés qui auront souscrit à ces Recommandations.

Les pays acheteurs pourront ainsi obtenir des pays producteurs des conditions avantageuses. En effet, le même matériel pourra répondre aux prescriptions de sécurité de tous les pays au lieu d'être étudié et fabriqué spécialement par chacun d'eux. Il y aura ainsi réduction du nombre de types fabriqués et par suite des prix meilleurs.

Et, en outre, lors de l'emploi, le personnel utilisant ce matériel obtiendra un meilleur rendement s'il se sent travailler sur des machines lui offrant une plus grande sécurité.

II - Quelques problèmes pratiques de mise en oeuvre de la normalisation dans un pays peu développé

Place d'une normalisation nationale dans les institutions du pays

La plupart des pays en voie de développement tendent à considérer la définition des normes nationales comme un acte de souveraineté, qui ne saurait résulter du simple jeu d'accords privés entre producteurs et usagers. Ceci s'explique assez aisément : soit par la faiblesse des mécanismes naturels de conception et d'élaboration des normes au sein d'organisations professionnelles rudimentaires ; soit encore par le souci de ne pas abandonner à des firmes, au contraire, trop puissantes, le pouvoir de déterminer sans contrôle les techniques nationales.

Cet état d'esprit se rencontre, en particulier, dans les pays nouvellement indépendants, où certaines normes des pays d'ancienne tutelle peuvent certes rester pratiquement acceptées pour les transactions courantes, mais sans que leur soit accordée officiellement la qualité de normalisation de référence. On peut d'ailleurs prévoir que, tôt ou tard, perdront même leur situation de fait celles de ces normes anciennes qui ne démontreront pas leur rattachement à une normalisation nationalement plus acceptable, - en général la normalisation internationale.

Cette évolution constitue pour ces pays une raison supplémentaire de porter attention aux travaux de la normalisation internationale. Il importe pour eux, en effet, d'éviter deux écueils également fâcheux :

- soit, par un nationalisme mal compris, de rejeter de leur économie des normes d'origine étrangère, certes, mais qui auront constitué et peuvent constituer encore une voie d'approche utile vers la normalisation internationale en cours de gestation;

- soit, par paresse et routine, de demeurer au contraire rattachés à des normes dont s'amenuisent les chances d'être un jour consacrées par cette même normalisation internationale.

Il est à peine utile de souligner à quel point de tels examens doivent être effectués dans un strict esprit d'objectivité, sous peine d'aboutir entre pays à une sorte de Tour de Babel fâcheusement anachronique. La normalisation est une oeuvre de technique, peu sensible aux fluctuations de la politique.

Cette considération, et beaucoup d'autres, conduisent à l'idée qu'il doit exister une certaine distinction entre l'autorité de l'Etat et la normalisation. Certes, dans tous les pays, il est reconnu de façon générale que l'appui de l'Etat est utile aux instituts de normalisation. Mais on admet le plus fréquemment que cet appui doit se limiter à ses aspects financiers (subvention) et administratifs (octroi aux normes nationales, en fait ou en droit, d'une reconnaissance de validité privilégiée). Il serait en particulier fâcheux que, dans les commissions techniques de normalisation, les inévitables oppositions qui se manifestent parfois entre les points de vue des producteurs et des usagers publics ou privés soient arbitrés par un acte d'autorité gouvernementale, et non par l'expérimentation ou la conciliation.

Ceci n'est pas moins vrai dans les pays en voie de développement que dans les autres, - bien qu'il semble acquis que, dans ces pays, les instituts nationaux de normalisation éprouvent des difficultés particulièrement grandes à se maintenir et à développer une activité efficace si l'Etat n'épaule pas fortement leurs efforts.

Le personnel d'un institut de normalisation

Techniquement, le problème de l'établissement, dans un pays sous-développé, de normes adaptées à ses particularités techniques et économiques pose rarement des problèmes insurmontables. Il s'agit de faire l'inventaire, puis la synthèse des connaissances des spécialistes nationaux, de rassembler les documents de normalisation internationale correspondants, ou à défaut les normes étrangères, de compléter ces données dans certains cas par consultation d'experts internationaux. Il suffit, en général, d'une petite équipe d'ingénieurs de normalisation pour coordonner ces données, en extraire des projets de normes valables et les soumettre aux procédures habituelles d'enquête, d'expérimentation et de mise au point, puis d'approbation et de publication sous forme de normes.

Malheureusement, la plupart des pays en voie de développement, pauvres en techniciens, peuvent légitimement hésiter à se priver de leurs services en faveur d'un Institut de normalisation dont la participation aux opérations concrètes de fabrication des produits est, il faut le reconnaître, assez lointaine, - au moins en apparence -. On fera observer à ce propos que l'ingénieur de normalisation, s'il doit avoir une formation technique valable, peut fort bien ne pas être un spécialiste ayant approfondi tous les détails des domaines industriels dont il a la responsabilité au point de vue normalisation. Son rôle est de mobiliser les connaissances des autres et non de faire prévaloir les siennes. Il est donc plus précieux de trouver chez lui une formation générale d'ingénieur : culture technique étendue, expérience d'ensemble des données industrielles caractéristiques du pays, - et surtout, sens psychologique avisé -. Or, l'expérience prouve que ces qualités sont répandues dans beaucoup de pays en voie de développement, dont les nationaux se caractérisant par une imagination riche et le goût des constructions intellectuelles. L'un des auteurs a présidé en 1961-62 à une expérience de formation d'ingénieurs de normalisation de divers pays en voie de développement par un stage spécialisé de cinq mois organisé à leur intention : il a le sentiment qu'à l'issue de ce stage, chacun des intéressés aurait constitué un collaborateur efficace et apprécié dans l'institut de normalisation de n'importe quel pays.

L'application des normes

Le dosage des mécanismes naturels et des mécanismes d'autorité dans la mise en application des normes est essentiellement variable de pays à pays.

Dans les pays industriellement évolués, on constate une certaine tendance à l'application des normes par le jeu de mécanismes naturels : loi de l'offre et de la demande, concurrence par la qualité, réflexes des bureaux d'études et services d'approvisionnement , éducation des usagers. Encore un pays comme la France ne se prive-t-il pas de renforcer ces mécanismes naturels par des mesures d'autorité lorsque ceci semble nécessaire.

Dans les pays en voie de développement, ces mécanismes naturels jouent habituellement peu. Aussi semble-t-il que l'autorité de l'Etat y sera, en règle générale, particulièrement utile au respect effectif des normes de l'Institut national de normalisation.

L'expression "autorité", toutefois, doit être prise dans son sens le plus large. A côté des mesures de coercition, peu propres à entourer la normalisation de l'atmosphère d'adhésion sympathique sans laquelle elle se développe habituellement mal, on peut concevoir un grand nombre d'interventionsplus subtiles : encouragements financiers, priorité dans les commandes, etc...

La création d'une marque nationale de conformité aux normes peut constituer une pièce maîtresse de cet ensemble de mesures concourant à promouvoir et à consacrer l'application des normes.

D'une façon générale, la normalisation, si simple qu'elle soit dans ses principes, constitue en soi une démarche supérieure de l'esprit industriel. C'est pour tout pays, quel qu'il soit, un pas en avant dans la voie du développement que d'avoir su concevoir et mettre en oeuvre une normalisation nationale. Il y a là tous les éléments d'une propagande nationale de bon aloi, susceptible d'obtenir l'adhésion des éléments actifs de l'industrie et de l'administration par appel à leurs sentiments les plus nobles.

III - Conclusion

Il importe que les dirigeants chargés de l'économie des régions peu développées se rendent compte de l'intérêt de la normalisation, qu'ils sachent faire comprendre cet intérêt à leur entourage, qu'ils développent l'enseignement des principes de la normalisation dans les écoles, qu'ils imposent l'achat par les experts de matériels normalisés, qu'ils encouragent la fabrication dans le pays d'articles normalisés. Comme le disait récemment M. VIATKINE, Président en exercice de l'ISO :

" La normalisation offre de très nombreux avantages pratiques et
" surtout dans le domaine des relations internationales puisqu'elle facilite
" les échanges commerciaux. Ces échanges sont devenus indispensables du fait
" que les pays se spécialisent dans la production de certains produits pour
" tenir compte de la répartition internationale du travail. En déterminant
" des caractéristiques essentielles uniques pour les produits finis, la
" normalisation contribue à unir les pays fabriquant ces produits. La normali-
" sation contribue par conséquent au rapprochement des peuples et les aide à
" établir entre eux des relations amicales."

Mais la normalisation doit permettre de voir plus loin et plus haut encore que les relations commerciales ou amicales entre les peuples, comme le disait M. CAQUOT, alors Président de l'ISO, à l'Assemblée Générale de cette organisation à New-York en Juin 1952 :

" La normalisation a un but très élevé, elle veut l'amélioration du
" niveau de vie de tous les groupes humains. Par là ils pourront parvenir
" à plus de spiritualité, car les lettres, les sciences et les arts ne
" peuvent s'épanouir que dans les civilisations où les besoins matériels
" sont préalablement satisfaits."

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France

STANDARDIZATION IN INDUSTRY

By Jean BIRLE,
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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

STANDARDIZATION IN INDUSTRY

By

JEAN BIRLE, GENERAL DIRECTOR OF THE
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INTERNATIONAL STANDARDS ORGANISATION (ISO)
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STANDARDS COMMITTEE (CNM).

SUMMARY

Development countries should through standardization be able to achieve, a means of passing more rapidly from the stage of craftsmen production and the uncoordinated importing of goods, to that of industrialisation, of the rationalization of agricultural products, and finally of the economy in general.

The first step toward standardization consists of the implementation of general and basic standards:
the terminology is of particular importance since the vocabulary of the development area under study does not as a rule include all the terms necessary for certain technical spheres;

in almost every industry, technical drawings constitute one of the most practical methods of expression. This method (of undeniable value to persons speaking the same language) becomes indispensable in international relations, because it is much more independent of the language than texts.

Finally, the units of measurement must be standardized, clearly defined, and easy to understand.

In a general way, standardization can in any country, usefully - and legitimately - become a gateway to what may be called general technical education.

The standardization of consumer goods represents a second stage in the work of standardization. It is applicable not only to machine-made articles for every day use, such as household utensils (pots and pans), small agricultural tools (saws, spades), small mechanical tools (hammers and pliers), but also to other industrial consumer goods such as furniture and textiles.

The standards of size and quality facilitate the free movement of supplies with a minimum of stock on hand and help avoid expenses entailed in the buying and storing of products which would not immediately be necessary for supplies.

As to articles of equipment, the problems facing the development areas are quite different, but standardization may be considered as necessary for these as it is for consumer goods.

The concept of equipment extends to the techniques of development, i.e. units, instruments and methods of measurement. For example, in irrigation, the ISO methods of measuring the flow of liquids would be used. The introduction of instruments

of measurement or tables of constants in non-metric units, into laboratories and quality control services of a country using the metric system, should be avoided.

Standardization is particularly concerned with the question of safety. The international unification of safety measures which the ISO is trying to achieve in cooperation with the BIT, will make it possible for the governments of the development areas to draw up their own safety requirements, based on these recommendations. The industrialized nations which have subscribed to these recommendations will comply with the proposed safety measures without difficulty.

With the beneficial effect of standardization in development countries thus established, the next point to be considered will be the practical problems raised by its implementation.

In all countries, it is generally accepted that the support of the government is necessary to the standardization bodies. This support must be solely financial (subsidies) and administrative (the granting, either de facto or de jure of a privileged recognition of the national standards). It is not really desirable, if during the meetings of the technical standardization committees, the inevitable differences that sometimes arise between the points of view of the producers and of the public or private consumers are settled by government decree rather than by experimentation and conciliation.

This is no less true in the development countries than in others - it seems to be a fact that, in these countries, the national standardization organizations encounter particularly great difficulties in holding their own and working effectively if the government does not vigorously support their efforts.

Technically, the problem of establishing standards adaptable to the technical and economic peculiarities of a development nation rarely poses insurmountable problems. An inventory must be made, then a summary of knowledge of the nation's specialists, the corresponding international standardization documents must be collected or in the absence of foreign standards, these data must in certain cases, be completed by consultation with international experts. A small team of engineers will generally suffice to complete this task.

The application of the standards raises more difficult problems. In the development countries the natural mechanics of application (law of supply and demand, competition by quality, reports of the study teams) are of less importance. Thus it would appear that the authority of the government will, on the whole, be particularly useful with respect to the effectiveness of the standards of the National Standards Institute.

The creation of a national brand of confirmity to standards can constitute an important feature of the combined measures for promoting and establishing the use of standards.

Standardization, so simple in principle, generally constitutes a significant achievement of industrial planning. For any country, it is a step forward on the road of development to have conceived and implemented national standardization. Therein lie all the elements of a good national publicity, which is likely to gain the support of the active elements in industry and government.

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Point de l'ordre du jour : D.8.2

France

L'INDUSTRIE DE L'ALUMINIUM DANS LA REPUBLIQUE FEDERALE DU CAMEROUN

Par J. RIBADEAU-DUMAS

Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

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3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

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L'INDUSTRIE de l'ALUMINIUM

dans la REPUBLIQUE FEDERALE du CAMEROUN

L'usine de production d'aluminium d'Edéa (45 à 50.000 t de métal par an) a été le premier investissement industriel important (l'équivalent de plus de 40 millions de $) concentré d'un seul jet entre le Sahara et le Congo. Les problèmes techniques, économiques et humains que cette installation a posés se retrouvent à peu de chose près pour tout investissement analogue dans ces régions.

L'usine est située à Edéa sur une île du fleuve Sanaga, à une centaine de kilomètres de Douala, capitale des affaires et port principal du Cameroun. Elle est implantée au coeur de la zone forestière subéquatoriale où le climat demeure tout au cours de l'année chaud et humide.

En décembre 1954, les deux grandes sociétés françaises spécialisées dans la production de l'aluminium, PECHINEY et UGINE, avec le concours des Autorités Camerounaises et celui de la Caisse Centrale de Coopération Economique, constituaient la Société "ALUCAM" COMPAGNIE CAMEROUNAISE de l'ALUMINIUM PECHINEY-UGINE. Cette entreprise avait pour but de produire annuellement 45.000 tonnes d'aluminium vierge par électrolyse de l'alumine.

Deux ans plus tard, l'usine d'aluminium la plus moderne du monde à cette date était construite, ouvrant ainsi la voie aux grandes réalisations industrielles qui ont vu le jour depuis lors ou qui sont actuellement en cours d'installation dans plusieurs Etats africains.

L'usine occupe une surface de 128.000 m^2 dont 80.000 sont couverts. Elle mesure 640 m de long sur 200 m de large. Elle comprend essentiellement une installation d'électrolyse avec actuellement 220 cuves Söderberg à 100.000 Ampères, mesurant chacune 9 m de long sur 4 m de large, réparties entre 4 grands halls parallèles longs de 600 m et larges de 15 m, chaque cuve produisant quotidiennement plus de 700 kg de métal à 99,5 % environ; une sous-station de conversion d'énergie où le courant livré par la centrale hydroélectrique en alternatif triphasé de 10.000 V est transformé en continu de 100.000 A environ, sous une tension maximum de 1.050 V; une fonderie comportant 4 groupes de 3 fours de 20 t. de capacité chacun; une usine à pâte pour la fabrication des électrodes; enfin, diverses installations annexes à fin technique ou administrative.

De 7.500 t en 1957, année de mise en service des premières cuves de l'usine, la production d'ALUCAM s'est progressivement élevée jusqu'à 47.500 t en 1961 et ce malgré les aléas inhérents aux années de démarrage de toute installation industrielle et en dépit d'une hydraulicité très déficitaire du fleuve Sanaga au cours des trois dernières années. Devant cet état de fait et pour être certaine d'assurer la production de 45.000 t/an prévue initialement, la Société, au cours de 1961, avait décidé de porter le nombre des cuves d'électrolyse de 208 à 220.

Raisons qui ont motivé l'implantation de l'usine :

Elles sont liées à l'accroissement considérable de la consommation d'aluminium dans le monde après la Guerre Mondiale : la production du métal repose sur un besoin considérable d'énergie électrique et sur le minerai de bauxite, qui doit avant électrolyse être transformé chimiquement en alumine. La bauxite et l'alumine sont aisément transportables alors que l'énergie l'est peu si - comme pour l'aluminium dont elle est l'agent de production - elle doit être livrée à très bas prix.

Les sources d'énergie hydroélectrique françaises et la plupart des européennes qui pouvaient être équipées afin de produire du courant à un prix de revient suffisamment bas pour l'utilisateur devenaient de plus en plus rares. Or, les réserves hydrauliques africaines étaient abondantes; mais leur équipement, loin des zones industrialisées, nécessitait de très lourds investissements. Les perfectionnements technologiques de l'organisation et des matériels de travaux devenaient tels cependant que la mise en chantier des barrages africains les plus "faciles à équiper" devait rendre possible un prix de revient du kWh compétitif avec celui des barrages européens devenus plus difficiles et coûteux.

C'est ainsi qu'autour des années 1950 l'intérêt le plus vif se porta sur les possibilités d'aménager des fleuves tels que le Konkouré et la Volta, particulièrement intéressants parce que proches de gisements de bauxite, et tels que le Kouilou ou le Congo. La "grande faim d'énergie" justifiait alors l'étude de ces immenses projets. L'europe et même l'Amérique du Nord considéraient la réserve hydraulique africaine comme un des supports possibles du développement industriel mondial. On doit reconnaître qu'à l'heure actuelle la progression de la consommation d'aluminium dans le monde s'est temporairement ralentie (elle n'a augmenté que de 3,75 % en 1961 par rapport à 1960 (1)) et qu'elle rend moins urgent l'équipement pour cette industrie de nouvelles grosses centrales hydroélectriques. A quoi il faut ajouter l'utilisation maintenant très au point du gaz naturel pour la production d'énergie électrique et l'apparition de l'énergie thermo-nucléaire dans des conditions économiques bientôt satisfaisantes : alors que vers 1960, elles n'entraient pas en ligne de compte, ces nouvelles sources d'énergie risquent à terme de se révéler de redoutables concurrents des équipements hydroélectriques.

Quoi qu'il en soit, dès 1947, la Société Energie Electrique du Cameroun avait conçu le projet d'installer sur le bas cours du fleuve Sanaga, dont l'embouchure est voisine de Douala, une centrale électrique comprenant 9 groupes de 11,4 MVA qui auraient fourni 850 millions de kWh en portant de 20 à 24 mètres la hauteur de chute du fleuve, avec un débit moyen de 500 m^3/seconde au moins.

Malheureusement, l'absence au Cameroun de réserves bauxitiques connues et par conséquent le manque d'utilisateurs locaux pour une quantité d'énergie aussi importante risquait de retarder la réalisation du projet. C'est pourquoi, en 1948, on décida d'en réaliser une partie seulement, c'est-à-dire d'exécuter les travaux de génie civil correspondant à trois groupes et de n'en installer que deux, dont un d'ailleurs serait encore aujourd'hui excédentaire par rapport aux besoins de la distribution locale. Ces travaux étaient terminés à l'automne 1953.

Si l'on se rappelle qu'en face de la grande "faim" d'aluminium, la mise en place de grands barrages africains nécessitait des délais de réalisation fort longs, on comprend que les Pouvoirs Publics et les producteurs d'aluminium aient envisagé alors l'étude de l'implantation au Cameroun d'une

(1) - alors que la production mondiale avait quadruplé entre 1946 et 1955.

industrie d'aluminium transformant de l'alumine importée; ainsi fut repris le projet initial de la centrale d'Edéa qui pouvait permettre d'obtenir dans des délais courts un relais nécessaire pour la production d'aluminium. En conclusion de cette étude, il fut décidé de reprendre l'équipement de la Sanaga sur les bases d'origine et d'édifier une usine d'aluminium d'une capacité de production d'environ 45.000 t/an, c'est-à-dire susceptible d'absorber toute la puissance électrique disponible fournie par le barrage, après satisfaction des besoins locaux.

Sur le plan économique, ce sont donc des raisons d'approvisionnement en énergie électrique, à une époque où il était devenu nécessaire d'en disposer rapidement, qui ont motivé la création de l'usine d'électrolyse d'Edéa. Le prix du kWh à produire se révélait en effet compatible avec les autres sujétions d'une entreprise impliquant, d'une part l'approvisionnement en alumine à partir de France et, d'autre part, l'exportation de métal sur les lieux de grande consommation, à quoi doit être ajouté que la construction elle-même des installations est plus coûteuse en pays neuf qu'en pays industrialisé.

En effet, les installations industrielles dans les pays insuffisamment équipés présentent de multiples aléas techniques, avec leur incidence sur les prix d'installation et par suite les prix de revient des produits, tous soumis à l'intense concurrence internationale : l'insuffisance des infrastructures portuaires, ferroviaires, routières (dont l'usine d'Edéa n'a d'ailleurs eu à souffrir que peu en raison de l'équipement du Cameroun) est un lourd handicap, comme la nécessité d'acheminer des pays industrialisés la totalité des matériaux et matériels, comme souvent des matières premières; de même, pour une industrie très spécialisée comme l'aluminium, l'obligation de faire venir au moins pour la construction et le démarrage tous les techniciens indispensables, avec les problèmes d'habitat - et parfois d'approvisionnement - que des collectivités transplantées peuvent poser, surtout dans des conditions climatiques différentes de celles des pays d'origine de ces techniciens.

Il faut également mentionner, dans l'ordre des difficultés à vaincre pour les grandes implantations industrielles, l'importance que revêt le problème des liaisons téléphoniques, télégraphiques et postales, tant internationales qu'intérieures, en particulier pour le service commercial de l'entreprise, notamment lorsque, comme pour l'aluminium, elle doit être à tout instant présente sur les marchés internationaux. Or, l'état des télécommunications ne lui permet pas encore toujours de disposer des informations nécessaires dans le minimum de temps. Aussi bien, les grandes industries installées dans ces pays doivent-elles souvent être aidées pour la vente de leurs produits par l'armature technique et commerciale d'organismes spécialisés de pays industrialisés. Ainsi d'ailleurs l'intégration des pays neufs dans les grands courants commerciaux de produits industriels nouveaux pour eux se trouve-t-elle réalisée d'emblée et aux meilleures conditions.

Eléments économiques :

Ceux-ci sont dominés par l'importance des financements que requièrent, en raison des sujétions des pays neufs, les gros investissements : à l'effet d'ailleurs d'attirer les capitaux disponibles, la quasi-totalité des pays neufs a su chercher des solutions adéquates juridiques et fiscales. En Afrique Noire, où les législations sont dans ce domaine très étudiées, le Cameroun avait été l'un des premiers Etats africains à reconnaître l'importance de ce problème et l'usine d'Edéa a été l'une des premières entreprises à recevoir des garanties de longue durée en matière de stabilité fiscale. Ainsi d'ailleurs a-t-elle pu, après l'investissement initial, poursuivre ses immobilisations (1).

Un autre problème économique réside dans la nécessité pour l'entreprise de s'assurer des débouchés à long terme susceptibles d'absorber régulièrement la production de l'usine. La demande croissante d'aluminium, on l'a mentionné plus haut, a été à l'origine de l'extension du barrage d'Edéa, la réalisation d'installations hydroélectriques n'étant concevable que si l'énergie est assurée d'être vendue en presque totalité et à long terme. En l'espèce, le problème de l'écoulement de la production se trouve déplacé du fournisseur d'énergie au producteur d'aluminium; c'est à ce dernier qu'il appartient en fin de compte de prévoir, avant même la mise en place des installations industrielles, les marchés qui absorberont la nouvelle quantité de métal produit.

Lorsque l'usine d'Edéa fut construite, il existait, rappelons-le, dans le monde un fort appétit d'aluminium; et si le rythme de cette demande est resté favorable sur certains marchés (dans la Communauté Europeenne notamment), cette situation n'est transitoirement plus générale dans le monde depuis quelques années. Grâce à ses relations avec les producteurs français et européens, ALUCAM a néanmoins pu écouler sans aléa sa production croissante depuis l'origine et semble à cet égard à l'abri de soucis.

Le rôle joué par ALUCAM dans la vie économique camerounaise est important. Outre que sa part dans la consommation d'énergie du pays est de 95 % de celle-ci, grâce à la production de l'usine d'Edéa, le Cameroun, avec 47.500 t. d'aluminium produites en 1961, vient au 4ème rang des pays producteurs de la Communauté Economique Européenne et des Pays Associés, derrière la France, l'Allemagne Fédérale et l'Italie, précédant des pays européens comme la Suisse et la Grande Bretagne.

L'usine d'Edéa vient en tête des activités industrielles du Cameroun. L'aluminium représente pour les échanges avec l'étranger, avec un trafic annuel d'environ 180.000 tonnes (importations et exportations) plus du cinquième du commerce extérieur du pays.

En tonnage, les importations de matières premières et matériel nécessaires à la production de l'aluminium représentent 30 % des importations et l'exportation du métal 12 % des exportations du pays.

Avec plus de 150 millions de tonnes kilométriques transportées chaque année entre Edéa et Douala, la Société représente le cinquième du trafic de la voie ferrée Douala-Yaoundé.

Il est difficile de donner un chiffre précis de l'enrichissement indirect dont bénéficie le Cameroun du fait d'ALUCAM. En effet, non seulement la Société contribue pour sa part à la masse fiscale générale, mais aussi elle permet

(1) - Sur ce point, comme d'une manière générale, le lecteur trouvera des éléments précis dans le Mémoire original officieux.

la perception de taxes et d'impôts sur les achats qu'elle réalise et sur les prestations de service auxquelles elle fait appel. Enfin, l'ensemble des salaires versés au personnel compte dans le pouvoir général d'achat de la population et fournit à son tour l'occasion de rentrées fiscales au bénéfice de l'Etat.

Eléments sociaux :

La mise en place d'une entreprise industrielle dans des pays neufs pose de nombreux problèmes sociaux : ceux qui résultent de la concentration du personnel (ALUCAM emploie 600 agents dans une région rurale) et des familles, et ceux de la formation de la main d'oeuvre et des cadres et de l'adaptation à la vie en usine.

L'entreprise ne peut évidemment envisager de rechercher sa main d'oeuvre ailleurs que dans le pays où elle s'installe, mais lorsqu'il s'agit d'un pays neuf, d'économie agricole dont les échanges sont relativement modestes, cette recherche pose des problèmes qu'il est indispensable d'évoquer. En effet, il n'existe pas localement de traditions industrielles. Les futurs ouvriers sont des hommes jusque-là insuffisamment employés et le plus souvent des agriculteurs auxquels la reconversion dans l'industrie apportera l'espoir d'un revenu plus élevé et plus régulier; mais cet espoir est souvent vague et le motif de la demande d'emploi est différent du désir d'acquérir un métier, que l'on rencontre dans les vieux pays. Les futurs ouvriers peuvent également être des artisans ou des jeunes sortant d'une école professionnelle, ou, enfin, des ouvriers non spécialisés; mais peu d'entre eux, quoi qu'il en soit, ont eu à connaître au cours de leurs précédentes occupations du fonctionnement d'une entreprise moderne, et encore moins des impératifs individuels qu'elle implique.

Sur le plan humain, en premier lieu, par conséquent le rôle de l'entreprise est considérable. Elle doit concevoir, avec de multiples nuances basées sur une connaissance approfondie et loyale du milieu, une politique sociale dont les éléments sont délicats. Cette politique devra tenir compte de ce que l'individu perd en changeant de vie et des compensations que sa nouvelle occupation devra lui offrir pour que sa personnalité n'en soit pas affectée.

Sur le plan professionnel ensuite, le futur ouvrier, employé ou cadre industriel, même s'il est titulaire d'un diplôme, devra apprendre ou réapprendre un métier et ce n'est que par un entraînement sur des postes de travail dans l'usine même qu'il finira par acquérir l'expérience indispensable et la connaissance des problèmes industriels. Cette adaptation à des fonctions différentes de ce qu'il avait connu antérieurement ou de ce qu'il supposait devoir connaître constitue un problème tout aussi important que ceux qui naissent des données techniques afférentes à la mise en place des installations proprement dites.

On ne saurait trop insister sur ce fait qu'une réussite technique sans réussite humaine serait vaine. Dans cette ligne de pensée, l'usine d'Edéa, par le développement de ses équipements sociaux pour ses agents et leurs familles, comme par des initiatives poursuivies sans relâche pour le remplacement de ses cadres européens par des Camerounais, s'efforce de traduire son activité industrielle et économique en amélioration du niveau d'existence des populations locales.

Dans la tâche difficile du développement mondial vers un meilleur avenir pour les hommes, vieux pays et pays neufs sont solidaires; mais l'apport des premiers aux seconds sera ou risquera de se révéler stérile s'il se limite à la technique, s'il n'est pas animé de la compréhension et du respect.

Eléments d'évolution :

Certains pensent que les grands ensembles industriels, ceux dans lesquels on peut classer l'aluminium, semblent avoir atteint pour un temps leur épanouissement. Et sans doute en effet la période de surproduction que le monde traverse, ou plutôt croit traverser, n'incite pas autant que naguère les investisseurs à créer de nouveaux grands ensembles, surtout si l'on se rappelle que leur création entraîne, la plupart du temps, une augmentation notable du chiffre de production mondiale des produits. Sans doute, les pays neufs conservent-ils indiscutablement toutes leurs possibilités dans ces domaines, mais la mise en oeuvre de ces dernières n'apparaît concevable que si les problèmes actuels de sous-consommation trouvent leur solution.

Faut-il dès lors s'abandonner au pessimisme ? Nous ne le croyons pas. A ce fléchissement - sans doute d'ailleurs temporaire - du dynamisme de l'expansion par le moyen des grandes réalisations industrielles, correspond certes une réalité : à ce mythe de la grande industrialisation, de plus en plus nombreux sont les esprits convaincus qu'il ne faut pas souscrire sans réserve. Et si paradoxal que cela puisse paraître, les réalisateurs de ces ensembles industriels ont été parmi les premiers à mettre en garde les pays neufs contre l'illusion de trouver dans l'implantation de grands investissements le remède universel au sous-développement.

Mais on n'en peut pas moins raisonnablement constater que ceux qui ont constitué de grands ensembles ont en même temps créé certaines des conditions du développement réel. Car les grands ensembles industriels - et le cas est typique pour l'industrie de l'aluminium - peu à peu se doubleront d'industries secondaires. A la suite de l'usine de production de lingots de métal vont se créer des entreprises de moindre importance qui se consacreront à la fabrication de produits finis ou semi-finis. Le cas est particulièrement net pour le Cameroun. Les producteurs français d'aluminium, en association avec des transformateurs et des acheteurs de métal, ont mis sur pied ou développé la fabrication locale de tôles d'aluminium ondulées et d'ustensiles ménagers. Mais il convient, pour que ces moyennes industries progressent, que les marchés locaux de consommation s'élargissent. Certains Etats africains, dans cet esprit, poursuivent opiniâtrement des campagnes de presse incitant les consommateurs à acheter de préférence les productions locales. De leur côté ainsi, ces nouvelles industries légères parviendront à livrer des produits à des prix concurrentiels à ceux des produits similaires importés.

Enfin, si les grandes installations industrielles ne peuvent se concevoir que parallèlement à de grands ensembles de consommation, il appartient aux pays en voie de développement de créer eux-mêmes ces grands ensembles par la suppression des barrières économiques multiples qui les isolent encore. La récente création de l'Organisation Africano-Malgache de Coopération Economique, les conventions intervenues par exemple entre l'Union Douanière Equatoriale et le Cameroun pour ne citer que ce que nous connaissons le moins mal, prouvent que les Etats africains ont pris conscience de cette nécessité.

Et si vieux et jeunes pays parviennent à trouver une solution au problème actuel de sous-consommation, si, de leur côté, ces mêmes jeunes pays savent transposer effectivement dans la réalité le potentiel économique qu'ils représentent, l'on est en droit d'espérer qu'à moyen terme le développement de ces grands ensembles industriels pourra connaître un regain d'activité.

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SUMMARY

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THE ALUMINIUM INDUSTRY IN THE FEDERAL REPUBLIC OF CAMEROUN

By J. RIBADEAU-DUMAS

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

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3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

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THE ALUMINIUM INDUSTRY IN THE FEDERAL REPUBLIC OF THE CAMEROONS

By
J. RIBADEAU-DUMAS

The Edéa aluminium works (which produces from 45,000 to 50,000 metric tons of metal per annum) was the first large-scale industrial investment to have been concentrated all at once between the Sahara and the Congo. The technical, economic and social problems thereby created are more or less common to all similar types of investment in this area.

The site chosen is in a sub-equatorial forest area less than 100 km. from Douala (the principal port of the Cameroons). The factory itself is 640 m. long and 200 m. wide and is powered by the CAMEROONS ELECTRIC POWER STATION the installed capacity of which has been increased for the purpose from 20,000 kW to 155,000 kW. It has thus been possible to make full use of the waterfall downstream of Edéa and the Electricity Company's original investment has been made profitable. The aluminium factory, which was completed in less than four years, consists of 220 tanks for the electrolysis of aluminium imported from Guinea, and of an electrode paste manufacturing plant, a foundry (which processes native ore for commercial use) and a large maintenance workshop. Approximately 90% of the equipment and machines are of French origin.

Considerations leading to the construction of the factory:

The construction of the factory is directly related to the considerable increase in world consumption of aluminium since the war: production is based on a considerable demand for electricity and on bauxite ore which must be chemically transformed into alumina prior to electrolysis. Bauxite and alumina can be easily transported whereas electricity hardly can be, if (as is the case with aluminium, of which it constitutes an essential element of production) it is to be available at a very low cost.

Reserves of cheap hydroelectric power (which have gradually become increasingly exhausted in the industrialised countries), are available on a large scale in Black Africa.

Moreover, although here it normally takes the form of great falls calling for prolonged surveys and large-scale investment of capital (e.g. Konkouré, Volta, Kouilou, Congo), the Edéa site lent itself to relatively easy harnessing of power enabling the achievement within a short space of time of the production of aluminium in quantities which, though relatively small, constituted nevertheless an auxiliary source of supply for a metal-starved world.

Today the problem might well be viewed in a different light, both because the world capacity for aluminium production is temporarily equal to the demand, and because the economic use of non-hydraulic sources of electric power (natural gas, nuclear energy) might well prejudice interest in large hydro-electric installations.

Technical Aspects:

It is in fact impossible to operate such huge installations (the construction of which is very costly) on an economic basis unless it is certain that the power produced will be fully and regularly consumed, and this can be true only of the very high consumption industries such as that of aluminium.

When industrial undertakings are established in countries which are not sufficiently equipped or developed, many technical hazards have to be overcome and these affect both the cost of the installation and the cost price of the products which have to face keen international competition: the inadequacy of harbour installations, railways and roads (the effects of which were felt only slightly by the Edéa factory in view of the facilities available in the Cameroons) constitutes a considerable handicap, as is the need to obtain equipment and plant and frequently even the raw materials themselves, from the industrialised countries. In addition (and this applies particularly to a highly specialised industry like that of aluminium), it is essential to bring to the spot all the key personnel required at least during construction and commissioning, thus entailing all the problems of housing and even of supplies which occur in the case of transplanted communities.

Economic Aspects:

The economic plane is dominated by the major problem of finance which, in view of the conditions obtaining in the newly-formed countries, calls for large scale investment. Nevertheless, nearly all the development countries have been able to devise adequate juridical and taxation solutions to this problem in order to attract available capital. In Black Africa, where great care has gone into the preparation of legislation on this point, the Edéa factory was among the first to receive long-term guarantees of tax stability. Thus, following the initial period of investment, it has been able to proceed with further expansion.

On the other hand, the Edéa factory uses nearly all the power supplied by the Edéa power station after the normal requirements of the public have been met, and is the leading industrial concern in the country.

Social aspects:

Technical success unaccompanied by human or social success would be vain indeed. From this point of view, the Edéa factory is making every effort to translate its industrial and economic activity into terms of an improved standard of living for the indigenous population by the development of social facilities for employees and their families, and by unrelenting effort to replace Europeans by Cameroon nationals.

Development:

Any threat represented by new sources of energy to the progress of the development countries by means of their hydroelectric resources should not be viewed pessimistically. Although the development of these countries is the responsibility of the modern world, this is nevertheless effected at present less through the medium of large-scale industrial undertakings than through the implementation of all possible improvements in the agricultural product, the diversification of crops and the creation of light industry. It is in this latter field that heavy industries like aluminium can be of assistance. In fact, industries for the processing of this metal are already being established and developed in the Cameroons.

There, as elsewhere, cooperation between the development countries themselves (and Africa is well aware of the effectiveness of this method) and between the development countries and industrialised countries, (especially with a view to solving the problems of under-consumption), will remain the touchstone for the future.

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